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DESCRIPTION

FLAT TUBE FOR HEAT EXCHANGER

Technical field

The present invention relates to an aluminum-made flat tube for heat exchanger having one or more partitions therein, of which cross section is formed in a nearly B-like shape or the like, in particular to an aluminum-made flat tube for heat exchanger, which is formed by bending a strip-shaped metal plate coated with a brazing metal at the outer surface side thereof in the width direction and formed with slits in a top portion of the partition for allowing the brazing metal at the outer surface side to enter into the inner surface side through the slits for brazing the partition and the inner wall surface.

Background Art

There is known a flat tube having a nearly B-like shape or the like in section, in which slits are intermittently formed in a top portion of a partition positioned in the central area thereof so as to allow a brazing metal at the outer surface side of the tube to enter into the inner surface side through the slits while brazing to integrally fix the top portion of the partition and the opposed inner surface of the tube by means of brazing; thereby the performance against the pressure is increased (for example, refer to Figs. 8 and 9 in Japanese Patent Application Laid-open No. 2002-228369).

When a corrosive fluid is circulated inside an aluminum-made flat tube, the inner surface side of the core metal of the flat tube is clad with a sacrificial anode material, and the outer surface side is clad with a brazing metal. In a flat tube having a nearly B-like shape in section, when a partition at the central area is formed in a manner of turn-up bending, the top portion and the inner side of the tube abutting thereon have to be brazed. In such case, the brazing metal at the outer surface side of the tube is allowed to enter into the inner surface side through slits formed in the top portion thereof.

However, from experiments conducted by the inventor, the following fact was found; i.e., in the flat tubes using slits, the reliability of the brazing largely varies depending on the length of the respective slits, gaps between the slits and the like, and the workability into a tube of B-like shape in section and accuracy thereof is largely influenced thereby.

Accordingly, an object of the present invention is to determine experimentally optimum conditions for the slits formed in the top portion of the partition in a flat tube having one or more partitions and formed into a B-like shape in section.

Disclosure of the Invention

An aspect of the present invention, disclosed in claim 1, is a flat tube for heat exchanger, which includes:

a pair of flat face portions (1) parallelly opposed to each other and a pair of curved portions (2) connected to both ends of the flat face portions (1) formed with a strip-shaped metal plate bent in the width direction thereof to form into a flat cylindrical shape,

wherein the strip-shaped metal plate is coated with a brazing metal (3) on one surface thereof, and is bent so that the brazing metal (3) is positioned at the outer surface side of the cylindrical shape;

in the central position in the width direction of one of the flat face portions (1), a turned-up portion (4) is bent up to the opposed flat surface side, and the top portion (5) of the turned-up portion (4) abuts on the inner surface of the opposed surface side to form a partition within the tube;

many slits (6) for allowing the brazing metal to enter therethrough are formed intermittently being separated away from each other in the top portion (5) in the longitudinal direction thereof,

wherein the length "c" of the slit (6) is 2 mm to 15 mm; the distance "e" between the edges of the neighboring slits (6) is 3 mm to 10 mm; and "e/c" is 0.6 or more.

Another aspect of the present invention, disclosed in claim 2, is the flat tube for heat exchanger according to claim 1, wherein the thickness of the strip-shaped metal plate is 0.15 mm to 0.6 mm.

The flat tube for heat exchanger according to the present invention has a structure as described above, and provides the following effects.

The flat tube for heat exchanger according to the present invention is structured so that the top portion 5 of the turned-up portion 4, which is formed in the central portion in the width direction of the flat face portion 1, abuts on the inner surface at opposite side thereto to form a partition in the tube, wherein many slits 6 are formed intermittently being separated away from each other in the top portion 5, and the length of the slits 6 is 2 mm to 15 mm; the distance between the edges of the neighboring slits 6 is 3 mm to 10 mm; and "e/c" is 0.6 or more. Accordingly, a highly reliable flat tube for heat exchanger having a satisfactory brazing strength between the top portion 5 and the inner surface at the opposite side, which provides a high performance against the pressure and which generates no deformation nor twist while the flat tube is being formed, is provided.

That is, since the length of the slits 6 is prescribed to 2 mm or more, the brazing metal reliably enters to the inner surface side through the slits 6 while brazing, the reliability on the brazing is ensured.

Since the length of the slits 6 is prescribed to 15 mm or less, the working accuracy to form the turned-up portion 4 by bending the strip-shaped metal plate in the

width direction thereof can be highly maintained; as a result, the reliability on the flat tube for heat exchanger can be maintained.

Also, since the distance between the edges of the neighboring slits 6 is prescribed to 3 mm or more, no crack is generated between the edges of the slits 6, a highly reliable flat tube can be provided.

Further, since the distance between the edges of the neighboring slits 6 is prescribed to 10 mm or less, the fillet of brazed point in the top portion 5 is formed satisfactorily while brazing, a flat tube for heat exchanger with high strength and performance against the pressure can be provided.

Brief Description of the Drawings

Fig. 1 shows a cross sectional view of a flat tube for heat exchanger according to the present invention, illustrating a relevant portion of a first embodiment.

Fig. 2 shows a cross sectional view illustrating the state of use of the flat tube after brazing.

Fig. 3 shows a perspective view schematically illustrating a turned-up portion 4 of the flat tube.

Fig. 4 shows an illustration of a strip-shaped metal plate before being shaped into the turned-up portion 4 of the flat tube.

Fig. 5 shows a cross sectional view illustrating a relevant portion of a flat tube for heat exchanger in a

second embodiment according to the present invention.

Fig. 6 shows a cross sectional view illustrating a relevant portion of a flat tube for heat exchanger in a third embodiment according to the present invention.

Fig. 7 shows a perspective view illustrating a state of use of a relevant portion of the flat tube in the third embodiment according to the present invention..

Best Mode for Carrying Out the Invention

Embodiments of a flat tube according to the present invention will be described referring to the drawings.

Fig. 1 shows a cross sectional view illustrating a relevant portion of a flat tube according to the present invention; Fig. 2 is a cross sectional view illustrating a state of use of a relevant portion after brazing; and Fig. 3 shows a perspective view schematically showing a turned-up portion 4 shown in Fig. 1.

The flat tube for heat exchanger is formed by bending an aluminum strip-shaped metal plate in the width direction into a nearly B-like shape in section. As for the strip-shaped metal plate, a brazing sheet is used. In the brazing sheet, the outer surface side of the core metal is coated with a brazing metal of an aluminum alloy up to approximately 10% of the total thickness of the plate; and the inner surface side of the core metal is coated with a sacrificial anode material of an aluminum alloy up to approximately 10% of the total thickness of the plate. The

total thickness of the strip-shaped metal plate is approximately 0.15 mm to 0.6 mm.

The flat tube 8 is formed in a cylindrical shape by a pair of flat face portions 1 opposed parallelly to each other and a pair of curved portions 2 with which both ends of the flat face portions 1 are connected. And in the central portion in the width direction of one flat face portion 1, a turned-up portion 4, which is bent up toward the opposed flat face side, is formed.

Both end edge portions 9 and 10 of the strip-shaped metal plate are overlapped with each other. One end edge portion 10 is formed in a stepped shape, and on the outer surface thereof, the inner surface of the end edge portion 9 abuts. The inner surface of the one end edge portion 10 abuts on the top portion 5 of the turned-up portion 4.

As shown in Fig. 1 and Fig. 3, in the top portion 5 of the turned-up portion 4, many slits 6 for allowing a brazing metal to enter therethrough are formed intermittently being separated away from each other in the longitudinal direction. The above slits 6 are formed in the following manner. That is, in a state of the strip-shaped metal plate before bending, the slits 6 are formed as shown in Fig. 4; and then the strip-shaped metal plate is bent back at the slits 6 as the center. Here, the length "c" of the slits 6 is 2 mm to 15 mm. Also, the distance "e" between the edges of the neighboring slits 6 is 3 mm

to 10 mm; and "e/c" is 0.6 or more.

Fig. 5 shows a cross sectional view of another flat tube for heat exchanger according to the present invention. The point different from the tube shown in Fig. 1, both end edge portions 9 and 10 of the strip-shaped metal plate are formed parallelly with respect to the turned-up portion 4; and the end edge portion 9, the end edge portion 10 and the turned-up portion 4 are overlapped with each other in the longitudinal direction of the tube section.

The slits 6 formed in the top portion 5 of the turned-up portion 4 are identical to those shown in Fig. 1 and Fig. 3.

Fig. 6 shows still another embodiment according to the present invention. In this embodiment, a turned-up portion 4 and a turned-up portion 4a are formed respectively by bending in the central portion in the width direction of a pair of flat face portions 1 being opposed to each other, and the respective top portions abut on each other. And in the top portion 5 of the turned-up portion 4, slits 6 are formed. The length of the slits 6 and the distance therebetween are identical to those shown in Fig. 1. In this embodiment, one end edge portion 9 and the other edge portion 10 of the strip-shaped metal plate are overlapped with each other at an end portion of the flat tube 8. In the above-described embodiments, a single turned-up portion 4 is formed to form a single partition. However,

two or more turned-up portions may be formed to form a plurality of partitions. Further, the joint structure of the partition may employ another mode. However, in the present invention, it is limited to the structure in which many intermittent slits 6 are formed in the top portion of the turned-up portion 4.

Many flat tubes as described above are disposed parallel to each other as shown in Fig. 7, fins 7 are disposed between the respective flat tubes 8, and both ends of the respective flat tubes 8 are inserted into tube insertion holes in tube headers (not shown) respectively. In a state that the heat exchanger has been assembled, the entire of the heat exchanger is placed in a high temperature furnace to melt the brazing metal on the outer surface of the flat tube 8, and then cool down the same to solidify; thereby the flat tubes 8 and the fins 7, the flat tubes 8 and the tube insertion holes are integrally fixed by means of brazing. At the same time, one end edge portion 9 and the another end edge portion 10 of the flat tubes 8 itself, and the top portion 5 of the turned-up portion 4 and the inner surface abutting thereon are integrally fixed by means of brazing.

Referring to Figs. 2 and 3, when the brazing metal 3 is melted in the furnace, the brazing metal at the outer surface side of the tube enters into the top portion 5 of the turned-up portion 4 from the slits 6, and continuously

fixes the top portion 5 and the inner surface of the tube abutting therewith in a brazing manner. Simultaneously, the outer surfaces of the overlapped turned-up portion 4 are also brazed integrally.

(Verification of numerical limitation in the present invention)

In the flat tube 8 according to the present invention, many slits 6 for allowing the brazing metal to enter therethrough are formed intermittently being separated away from each other in the longitudinal direction of the top portion 5. The length "c" of the slits 6 is 2 mm to 15 mm; the distance "e" between the edges of the neighboring slits 6 is 3 mm to 10 mm; and "e/c" is 0.6 or more. The above values were obtained as the optimum values in the present invention on the basis of the following experiments.

As the samples for the experiments, flat tubes 8 shown in Fig. 1 were formed. The longer diameter of the section was 24 mm; and the shorter diameter thereof was 2 mm. The thickness of the plate was 0.2 mm, 0.3 mm and 0.4 mm respectively.

[Table 1]

Sample	Slit length c (mm)	Gap e (mm)	Brazing performance	Workability	e/c	Judgment
(1)	2	3	O	O	1.5	O
(2)	2	5	O	O	2.5	O
(3)	2	8	O	O	4.0	O
(4)	2	10	O	O	5.0	O
(5)	4	3	O	O	0.75	O
(6)	4	5	O	O	1.25	O
(7)	4	8	O	O	2.0	O
(8)	4	10	O	O	5.0	O
(9)	8	5	O	O	0.63	O
(10)	8	10	O	O	1.25	O
(11)	12	8	O	O	0.67	O
(12)	12	10	O	O	0.83	O
(13)	15	9	O	O	0.6	O
(14)	15	10	O	O	0.66	O

O: acceptable X: unacceptable

[Table 2]

Sample	Slit length c (mm)	Gap e (mm)	Brazing performance	Workability	e/c	Judgment
(15)	1	1	X	X	1.0	X
(16)	1	3	X	O	3.0	X
(17)	1.5	3	X	O	2.0	X
(18)	1.5	6	X	O	4.0	X
(19)	2	2	O	X	1.0	X
(20)	2	12	X	O	6.0	X
(21)	2	20	X	O	10.0	X
(22)	4	2	O	X	0.5	X
(23)	4	12	X	O	3.0	X
(24)	4	20	X	O	5.0	X
(25)	8	2	O	X	0.25	X
(26)	8	4	O	X	0.5	X
(27)	8	12	X	O	1.5	X
(28)	8	20	X	O	10.0	X
(29)	12	2	O	X	0.16	X
(30)	12	5	O	X	0.42	X
(31)	12	7	O	X	0.58	X
(32)	12	12	X	O	1.0	X
(33)	12	20	X	O	1.67	X
(34)	15	2	O	X	0.13	X
(35)	15	5	O	X	0.33	X
(36)	15	8	O	X	0.53	X
(37)	15	12	X	O	0.8	X
(38)	15	20	X	O	1.33	X
(39)	17	5	O	X	0.29	X
(40)	17	10	O	X	0.58	X
(41)	17	15	X	O	0.88	X
(42)	17	20	X	O	1.18	X
(43)	20	5	O	X	0.25	X
(44)	20	10	O	X	0.5	X
(45)	20	15	X	O	0.75	X
(46)	20	20	X	O	1.0	X

O: acceptable X: unacceptable

The thickness of the brazing metal 3 coated on the respective outer surfaces was 10% of the total thickness of the plate. As shown in table 1, as for the flat tubes according to the present invention, various flat tubes of which slit length "c" was 2 mm to 15 mm were formed, and prepared so that the length (gap) "e" between the edges of the slits was 3 mm to 10 mm; and "e/c" was 0.6 or more.

Also, as the samples for comparison, as shown in table 2, various samples other than the flat tubes according to the present invention, of which slit length "c" was 1 mm to 20 mm, were formed and prepared so that the edges length (gap) "e" between the slits was 1 mm to 20 mm.

The length of the tubes for experiments was 60 mm. The tubes were placed in a high temperature furnace to melt the brazing metal and then cooled down. The state of the brazing was examined.

As demonstrated in table 1 and table 2, in the aspect of the brazing performance, satisfactory results were obtained in the following range; i.e., slit length "c" was 2 mm to 20 mm; and the distance "e" between the edges of slits was 2 mm to 10 mm. That is, fillet of brazed point having a satisfactory strength was formed entirely in the top portion 5 of the turned-up portion 4 and the performance against the pressure was ensured.

Contrarily, in the cases that the slit length "c" was 1 mm or 1.5 mm, the brazing metal failed to enter

satisfactorily through the slits and defective brazing was found. In the case where the distance "e" between the edges of slits was larger than 10 mm, it was found that a portion without fillet of brazed point (not brazed portion) exceeded 1/3 of the distance "e" between the edges, and the total strength of the flat tube was not satisfactory. The reason of the above is as described below. That is, in the portion with no slit between the edges, the fillet of brazed point was formed with the brazing metal, which entered through the slits while brazing, and the length of the entered metal was constant. Accordingly, when the distance between edges is too large, a large portion having no fillet of brazed point was made resulting in a reduced strength.

The same results as the above were obtained in any of the following cases; i.e., the thickness of the plate of the tube was 0.2 mm, 0.3 mm or 0.4 mm.

In the aspect of the workability of the tube, as shown in tables 1 and 2, the length of the slits has to be 15 mm or less; and the distance "e" between the edges of slits has to be 3 mm or more; and "e/c" has to be 0.6 or more. When the above ranges are exceeded, cracks or twists are generated between the edges of slits while the flat tube is being formed and is not suitable to be used as the flat tube. That is, when the length of the slits exceeds 15 mm, cracks or twists are generated while the flat tube is being

formed. Also, when the distance between the edges of slits is 2 mm or smaller, cracks are generated while the flat tube is being formed. Further, when the "e/c" is smaller than 0.6, cracks are generated while the flat tube is being formed.

The same results as the above were obtained in any of the following cases; i.e., the thickness of the plate of the tube is 0.2 mm, 0.3 mm or 0.4 mm.

Accordingly, it was experimentally verified that the optimum conditions that satisfy both of the brazing performance and the workability are as below; i.e., the slit length "c" is 2 mm to 15 mm; the distance "e" between the edges of slits 6 is 3 mm to 10 mm; and "e/c" is 0.6 or more.